UNIVERSITY OF PENNSYLVANIA

A STUDY OF TEST RESULTS AT THE THIRD AND FIFTH GRADE LEVELS

DALLAS EYRE BUZBY

A THESIS

IN PSYCHOLOGY

PRESENTED TO THE FACULTY OF THE GRADUATE SCHOOL IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

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A STUDY OF TEST RESULTS AT THE THIRD AND FIFTH GRADE LEVELS

By DALLAS EYRE BUZBY

INTRODUCTION

This study is based upon standards of performance secured by testing children in the fifth and third grades of Philadelphia and its environs. Murphy[1] tested 500 fifth grade children and published his results in this journal. He points out that the chronological ages represented run from eight to seventeen years, and mentions that the children tested do not represent a homogeneous group either in respect to chronological age or school proficiency. He characterizes this level as that of "liminal intellectual efficiency" and states that the child's progress through the grades "is differentiated through surpassing intellectual levels." Standards, not yet published, were also secured by Genevieve McDermott Murphy by testing 500 children in third grade classes. She found the chronological ages to run from seven years and two months to fourteen years and eight months. In the reports of both of these investigations, the data were presented in decile form. Standards were thus secured for chronological age and mental age, for Intelligence Quotient, for memory span (audito-vocal forward and reverse and visuo-vocal) and for the first and second trials at the Witmer Formboard, Witmer Cylinders, and Dearborn Formboard. The investigation of the fifth grade children also included an arithmetic test.

The first objective of the present study is to find out whether a group more homogeneous in test scores could be obtained by

[1] Murphy, Miles, The Ten Year Level of Competency. *Psychological Clinic,* 1928, 17, 33–60.

limiting the range of chronological ages. In other words, the problem was to find out whether by increasing the homogeneity of the group in respect to age, we limit the variability in test scores. The results were subjected to statistical treatment. The effort was then made to determine whether any relationship would be found to exist between the relative intellectual efficiency of children within the fifth grade and their proficiencies in the respective tests.

The word "proficiency" is here employed as used by Dr. Lightner Witmer.[2] He defines "proficiency" as relative superiority demonstrated and expressed in terms of relative superiority or inferiority to other members of a group. It is a quantitative measure. The relative proficiency, at the Witmer Formboard, of an individual subject within the fifth grade may be expressed by stating the decile upon the table of norms for that grade within which his score places him. When we assert that a child falls within a group superior to 70 per cent and inferior to 20 per cent of fifth grade children, on the basis of time required for successful performance of the test we are stating his proficiency or relative superiority at the Witmer Formboard. Nothing is thereby mentioned as to the qualitative aspects of the performance. These aspects are very important but do not lend themselves to statistical treatment. The phrase "relative intellectual efficiency" is suggested by Murphy's description of the ten-year-old child as possessing "liminal intellectual efficiency." The concept which the phrase "relative intellectual efficiency" is intended here to express will be discussed later.

Part I

Procedure

In the first place in order to obtain a group of fifth grade children more homogeneous in chronological age, the method adopted was to eliminate the deciles which varied most from the median chronological age. The middle 40 per cent of the age range was found to include those ages from ten years and four months to eleven years and six months. Upon the suggestion of Dr. Witmer the test results of the children whose chronological ages fell within this middle 40 per cent were first studied. By this procedure there were excluded both those considerably accelerated and those con-

[2] Witmer, Lightner, Psychological Diagnosis and the Psychonomic Orientation of Analytical Science. *Psychological Clinic*, 1925, 16, 1–18.

siderably retarded for grade. There were 215 individuals in this group selected for study which will be referred to hereafter as "group II." The original group of 500 cases will be called "group I." The various sets of data for group II have been deciled, after the method of Murphy and others. The age range of group II was then further reduced by selecting those cases within the group whose chronological ages fell between ten years and seven months and eleven years inclusive. These limits represent the middle forty per cent of group II in chronological age. This smaller group consisted of 98 cases and will be designated as "group III." The same method of selection was followed with the third grade. In this grade group I consisted of 496 cases from seven years and two months to fourteen years and eight months of age; group II consisted of 211 cases from eight years and six months to nine years and four months of age; group III consisted of 115 cases from eight years and eight months to nine years of age. The decile tables for all these groups follow the body of this article.

It is generally regarded as a valid assumption that the ability required for success at school is intellect, which Dr. Witmer defines as the ability to acquire, retain, organize, and use knowledge. In the case of groups II and III we have two factors which are relatively constant: (1) sameness of grade, i.e., the attained level of intellectual achievement, and (2) the range of age—fifteen months for group II and six months for group III. In the case of group I only the grade level is constant. It would seem legitimate to expect a much less wide scatter in test scores if proficiency in the tests and relative intellectual efficiency depend upon the same factors. The decile tables, however, show that we do not find a limitation in range of scores at all in proportion to the limitation in the range of chronological ages, as will be pointed out later.

We find in examining the fifth grade tables that while extremes in I.Q. especially are cut off a wide variation in scores is still found. Group III, with a variation in chronological age of only six months, still shows a range of from 2 to 6 in reverse memory span. The very low audito-vocal forward span of 3 is still included. The range of I.Q. is somewhat restricted, the lower limit being 71 for group II and 80 for group III. Groups II and III retain the range of from 0 to 100 in "arithmetic." The decile values for the performance tests are very similar throughout the three groups. If we compare scores at the Witmer Formboard, we find in the case of groups I and III that the decile values are the same in four

places. This is true for both the first and second trials. The most that may be said of the performance test scores is that some of the better and some of the poorer scores are eliminated. In some cases the upper deciles tend to be a little poorer and the lower deciles a little better than in the case of group I.

Treatment of Results

The problem is to find out whether group II, the middle 40 per cent of group I in chronological age, is more homogeneous in test scores than group I; also whether group III, the middle 40 per cent of group II in chronological age, is more homogeneous than group II. In order better to interpret such differences as may exist between the groups in test scores, the raw scores were treated statistically.[3] The tables show the results obtained in terms of mean, sigma, skewness, and coefficient of variation. It seemed to be desirable to make these calculations in the case of I.Q., mental age, visual memory span, Witmer Formboard (first trial), Witmer Cylinders (first trial), and Dearborn Formboard (first trial).

The reason for the choice of I.Q. and of the non-verbal performance tests as bases for the comparison of group and sub-groups is obvious. The mental age was retained as a basis for comparison, as it represents the total score of tests passed in the Binet-Simon scale. The visual memory span, rather than the auditory, was chosen because it had been discovered by Murphy that the greatest differences in memory span between the first[4] and fifth grade children were in visual memory span. By the time the child reaches the fifth grade the visual span is pretty consistently one more than the auditory span and it was thought that the visual memory span might bear some relationship to what we are designating "relative intellectual efficiency." Actually the difference between the average visual and the average auditory spans was found to be 1.16 for group I; 1.18 for group II; and 1.08 for group III. The median visual memory span for each group is 7 and the median auditory span is 6.

The best means of comparing the groups with respect to homogeneity is to examine the values of sigma and of the coefficient of

[3] The writer wishes to express his appreciation to Dr. Morris S. Viteles of the Department of Psychology of the University of Pennsylvania, for valued suggestions given as to the statistical treatment of results.

[4] Easby-Grave, Charlotte, Tests and Norms at the Six Year Old Performance Level. *Psychological Clinic*, 1924, 15, 261–300.

variation. Garrett [5] states that the sigma is of value when the highest reliability is desired and when due weight must be given to extreme deviations. Employing these measures as criteria, we do find an increasing homogeneity from group I, through group II, to group III, in the case of I.Q. and of the Witmer Cylinders. The sigma values for I.Q. are respectively 16.8, 12.8, and 11.5. The values of the coefficient of variation are respectively 16.9, 12.7, and 11.1. With the Witmer Cylinders the elimination of variability is somewhat less evident. These measures appear in Tables I and V. In the case of mental age, visual memory span, the Witmer Formboard, and the Dearborn Formboard, an increase in homogeneity is either absent or negligible. In tables I to IV, at the third grade level, we meet with similarly negative results. The method of forming the groups, it will be remembered, is analogous to that employed for the fifth grade groups.

On the basis of sigma and of the coefficient of variation, possibly we might infer that our derived groups are more homogeneous than is the whole group with respect to I.Q., and test scores at the Witmer Cylinders, at the fifth grade level. At the third grade level, the derived groups may be slightly more homogeneous with respect to I.Q. and scores at the Witmer Formboard.

In order to examine more critically such differences as are found, further recourse was had to statistical treatment, as we are here concerned with the reliability of the obtained measures. We must investigate the reliability of the obtained means; their probable divergence from the true mean which we should get if we could test all fifth grade children. The P.E. of the average serves as an index of reliability of the obtained mean. These obtained indices appear in the tables. Next we are interested in the reliability of the difference between the obtained means which is secured by the use of other formulæ. Since we are concerned with the difference between the means of a whole group and sub-groups, the following complex formula was used instead of the usual formula employed when quite diverse groups are involved:

$$\sigma \text{ diff.} = \sqrt{\frac{\sum^2}{N} + \frac{\sigma^2}{n}\left(1 - \frac{2n}{N}\right) - \frac{n(M - m)^2}{N(N - n)^2}}$$

[5] Garrett, Henry E., Statistics in Psychology and Education. New York: Longmans, Green and Co. 1926.

$\sum$ = standard deviation of the total group.
N = number of cases of the total group.
σ = standard deviation of the sub-group.
n = number of cases of the sub-group.
M = average of the total group.
m = average of the sub-group.

The sigma differences are shown in the tables. To determine the chances that the obtained difference between the means of the group and of the sub-groups under consideration represents a true difference greater than zero, the obtained difference is divided by the sigma difference, employing the formula $\frac{\text{difference (means)}}{\text{sigma difference}}$. Hereby is secured a value which we shall call "*z*"—an index of significance. By means of a special table [6] we can read off the number of chances in 100 that the true difference between the group and the sub-groups is greater than zero. To be certain, 100 chances in 100, the product—"*z*"—of this division must be at least 3. The tables show the "*z*'s" for each sub-group.

Only in the case of I.Q. and of mental age do we secure or approach the required degree of certainty. There are 99.8 chances in 100 that there is a real difference with respect to I.Q. between the whole group and group II. The index of significance was 2.9. In the case of group III, with an age range of six months, we secure a "*z*" of 3.5, indicating complete reliability of the obtained difference, as indicative of a true difference greater than zero, between this sub-group and the whole group. In regard to mental age: the chances are 96 in 100 in the case of group II ("*z*" equals 1.7) and 99 in 100 ("*z*" equals 2.38) in the case of group III that there is a true difference between group and sub-group. For the Cylinder test, the chances are 82 in 100 and 88 in 100 respectively in the cases of groups II and III of a true difference greater than zero between group and sub-groups. The "*z*'s" are .92 and 1.23. It was mentioned that, at the third grade level, there is some suggestion of an increase in homogeneity in I.Q. and scores at the Witmer Formboard in the case of the derived groups. However, we cannot be certain of the reliability of the obtained differences as indicative of a true difference.

At this point reference may be made to a report of Fernberger [7]

[6] Garrett, *op. cit.*, p. 134.

[7] Fernberger, S. W., Statistical and Non-Statistical Interpretation of Test Results. *Psychological Clinic*, 1922, 14, 68–72.

in which he attempted to determine the degree of statistical validity in regard to some of the findings of Leaming [8] in her study of the fifteen-year-old level. In spite of the fact that she found rather marked differences between the averages of different groups in some of the tests, Fernberger, using statistical formulæ analogous to those here employed, found none of her differences to be statistically significant. His explanation of this is that inasmuch as in each of the distributions there is found a wide variation in test results, the probable errors of the differences become so great that a large "*z*" cannot be obtained. He concludes that mental tests show such a degree of variability within a relatively homogeneous group that the differences between the groups do not have statistical significance. In our tables, it is shown that the sigma difference, corresponding to Fernberger's P.E. difference, is frequently large, especially in the case of the performance tests. In other cases we do obtain a value of "*z*" nearly or quite as great as the required 3. It is possible that by the use of the formula employed in our study, a higher value for "*z*" may be obtained, in which case it is possible that some factors are omitted of which cognizance should be taken. At any rate, it is felt that if our conclusions must ultimately be based upon inspection of the actually obtained differences between the averages of group and sub-groups, and upon inspection of the decile tables, we should not be inclined to infer more significance to these differences than the "reliability" formulæ would warrant. Reference to the tables will show how little the obtained measures for the first three groups vary.

Summary

To sum up the findings thus far, it may be said that by cutting down the ranges in chronological age of the children of the fifth and of the third grades which had been tested, we do not get a more homogeneous group except in respect to I.Q. and perhaps in mental age, at the fifth grade level. Inasmuch as the I.Q. is regarded as a measure of intellectual proficiency, we should expect to find a relationship between constancy in academic standing and constancy in respect to I.Q. By "constancy in academic standing" reference is made to the fact that we are dealing with children of approximately the same age and of the same level of intellectual proficiency as measured by grade in school. Greater constancy

[8] Leaming, R. E., Tests and Norms for Vocational Guidance at the Fifteen Year Old Performance Level. *Psychological Clinic*, 1922, 14, 193–220.

with respect to I.Q. is shown by the lessened values of the sigmas and of the coefficients of variation, in the case of groups II and III. That there is a real difference in I.Q. between groups I and III has been established. Since mental age is a concept so hard to define, it may be well to leave it out of our consideration at this time. As far as these three groups are concerned, there does not appear to be a discernible difference in proficiency at the performance tests. So it seems permissible to draw this conclusion as a result of the work done in this part of our investigation: for practical purposes essentially the same results would be secured as norms for fifth grade children if those composing the middle 40 per cent in the range of chronological age were tested as were secured by testing the larger number. Nearly the same norms would be secured by testing the middle 40 per cent of these, or approximately the middle 20 per cent of the total group. This is not true of I.Q. It is interesting that with this increase in homogeneity from group I, through group II, to group III with respect to I.Q., there is a rise in average I.Q. from 98.9 for group I to 101.3 for group II to 103.1 for group III. These sub-groups do not appear to be superior in the non-verbal performance tests. Apparently this conclusion would be true also of third grade children.

The reverse of this conclusion is the inference that in so far as the children tested are representative of fifth and of third grade children, these norms which are used in the Psychological Clinic of the University of Pennsylvania are adequate standards for what should be expected of children within the fifth and third grades, particularly of those whose chronological ages lie within the middle 40 per cent median-modal group.

At this point attention should be drawn to two problems which presented themselves for consideration. Some of the curves are extremely skewed; especially those for the Cylinders and for the Dearborn Formboard. This is caused by the fact that the mean, median, and modal scores fall well toward the low end of the range of scores and by the failures which are found. The second problem was how to treat the failures. Being unable to find in the literature any precedent as to the treatment of failures in the assembling of statistical data, it was decided to make two sets of calculations; one omitting failures and the other retaining the failures but regarding them as occurring within the step-interval next above the highest step-interval within the range of successful scores. Where two sets of numbers appear in the tables for a given statistical

measure, the numbers representing the measure "without failures" are printed in italics.

Part II

A Comparison of Three More Sub-groups, with the Total Group, in Terms of the Verbal Test Scores

In the case of groups II and III we were concerned with children of approximately the same age, the ranges being respectively fifteen and six months. The intellectual level of the 500 fifth grade children tested may be regarded as having been raised to a certain level of achievement by the fact of inclusion within the fifth grade. All of the children successfully doing the work of the fifth grade have attained this level as measured by grade. However, our whole group of fifth grade children, ranging in age from eight years and eleven months to seventeen years and three months, must include many children considerably accelerated and many considerably retarded for grade. Some of them may have required a period of time twice as long as that required by others to reach this level. Regarding progress through the grades as a demonstrated proficiency in terms of "surpassing intellectual levels," the amount of acceleration or of retardation for grade would seem to furnish one index of relative intellectual efficiency. If we are interested in the relative intellectual efficiency of groups of children within the fifth grade, we must consider two factors which are involved. The constant factor is grade standing; chronological age is the variable. The ratio of the higher chronological ages of the retarded children to this grade level will differ from the ratio of the lower chronological ages of the accelerated children to this same level. In terms of this ratio the retarded children may be regarded as relatively lacking in intellectual efficiency and the accelerated children as relatively high in intellectual efficiency. Reference is made to this ratio when the phrase "relative intellectual efficiency" is employed. It may at first appear that the words "proficiency" and "efficiency" as employed in this investigation are really synonymous. It seems possible, however, to discern a shade of difference in meaning whereby the word "efficiency" is preferable when referring to the relationship between grade and age. By "fifth grade proficiency" we mean demonstrated ability to do fifth grade work. "Efficiency," retaining something of its mechanical signification, seems to include also the factor of time and effort involved in reaching this level of achievement.

Since limitation in the range of chronological ages was found not to result in a corresponding limitation in the range of test scores, it is evident, as we should expect, that not the same factors are contributory to proficiency in each of the tests and to rate of progress through the grades. It seemed worthwhile, therefore, to compare the test scores of the accelerated pupils and of the retarded ones; to learn in which, if any, of these test scores a relative proficiency or deficiency would be found corresponding to the relative acceleration or retardation for grade as the case might be. If the accelerated children should be found to be relatively superior to the retarded children in respect to any test or tests and the retarded children relatively inferior in the same, we might assume some relationship between the abilities making for acceleration at school and for proficiency at the particular test or tests. If both of these groups of children should give very similar results in a given test, there would seem to be little or no relationship between the abilities required for progress through the grades and for relative proficiency in the tests; or else that still other factors entering in played a dominant rôle.

In view of the results which were obtained, it seemed advisable for greater clarity in presentation to treat first the findings in respect to I.Q., mental age, and visual memory-span; leaving for later consideration the discussion of the performance test results. Consequently three more sub-groups were separated out for study. Group IV consisted at each grade level of the upper thirty per cent of the chronological age distribution, group V consisted of the lower thirty per cent of the chronological age distribution, and group VI consisted of a group specially selected on the basis of reverse memory span. At the fifth grade level group IV consisted of 148 cases with chronological age ranging from eleven years and seven months to seventeen years and three months; group V consisted of 137 cases with chronological age ranging from eight years and eleven months to ten years and three months; group VI consisted of those cases having a reverse memory span of 5 or 6. At the third grade level group IV consisted of 138 cases with chronological age ranging from nine years and five months to fourteen years and eight months; group V consisted of 147 cases with chronological age ranging from seven years and two months to eight years and five months; group VI consisted of those cases having a reverse memory span of 4 or 5.

The raw scores were treated statistically in the same manner as

were those of groups II and III in the first part of this study. The statistical measures appear in the tables in the columns marked "IV" and "V." The sigma differences and the "z's," resulting from the division of the sigma differences into the differences between the means of group and sub-group, also are shown. In each case we are comparing the sub-group IV or V with the whole group, group I.

Group IV

Group IV, which for convenience we shall call the "old" group, is significantly poorer than the whole group in I.Q., mental age, and in visual memory span. The average I.Q. at the fifth grade level is 83.3 and the median is 83. The index of significance—"z" —is far in excess of the required 3. It is true that this "old" group is overweighted in chronological age, which would tend to lower the I.Q. The average mental age also is four months below that of the whole group and the "z" of 4 denotes reliability. In visual memory span also, this group is inferior and there is a real difference. The average and median audito-vocal forward spans also are lower for this group. If memory span is indicative of complexity of mental organization,[9] or of native ability to organize knowledge, we are not surprised to find a correspondence between relative intellectual deficiency in terms of school progress and relative deficiency in visual memory span. At the third grade level we find group IV, again the "old" group, significantly inferior in I.Q., apparently inferior in visual memory span, and slightly although not significantly superior in mental age. This slight superiority in mental age would appear to be an anomaly. The thought is suggested that the tests of the Binet-Simon scale up to and including the nine-year level—a mental age of nine years being roughly the mean and median for third grade children—are not yet of a sufficiently intellectual nature to weed out the non-intellectuals. The separation of the sheep from the goats by the Binet-Simon scale appears to be more thorough at the higher age levels.

These results seem to indicate that the retarded children who are relatively inefficient in intellectual achievement, as we are defining this concept, are relatively deficient in comparison with the whole group, in respect to I.Q., mental age, and visual memory span. This relationship is less definite at the third grade level and does not hold in respect to mental age.

[9] Brotemarkle, R. A., Some Memory Span Problems—An Analytical Study at the College Adult Level. *Psychological Clinic*, 1924, 15, 229–258.

Group V

This group, called for convenience the "young" group, is composed of 137 cases ranging in chronological age from eight years and eleven months to ten years and three months, representing the lower 30 per cent in age of the whole group at the fifth grade level. This group is significantly better than the whole group in I.Q. and visual memory span and slightly better, apparently, in mental age. This group appears to be relatively homogeneous with respect to I.Q. The standard deviation and the coefficient of variation are relatively low as compared with the whole group. However the range in I.Q. is from 71 to 156. A superiority in respect to mental age is probable, although not statistically certain. The median mental age of the group is eleven months in excess of the median chronological age of ten years. The average chronological age is nine years and ten months. Jones [10] in her study of 120 superior children states that her group shows a median acceleration of five years in mental age over chronological age. Our "young" group is significantly better than the whole group in visual memory span. At the third grade level group V, ranging in chronological age from seven years and two months to eight years and five months, proves to significantly better in I.Q. and slightly, although not significantly, better in visual memory span. The mental age is again anomalous. The "young" group appears to be slightly, although not significantly, inferior to group I and to the "old" group. Is there again an evidence that the Binet-Simon scale at the lower year levels is not very discriminative of intellectual differences?

The "young" group, therefore, gives us a positive relationship between relative intellectual efficiency and relative proficiency in respect to I.Q. and visual memory span. In the case of the "old" group there was a relative deficiency in I.Q., mental age, and visual memory span at the fifth grade level. Jones states that in all forms of the memory span used, the median of her superior group was that of the high school level. That our "young" accelerated group is superior in visual memory span suggests, apart from the pedagogical acceleration of the group, that we are here concerned with children possessing some measure of intellectual superiority.

[10] Jones, Alice M., An Analytical Study of One Hundred Twenty Superior Children. *Psychological Clinic*, 1925, 16, 19–76.

Group VI

Since we are interested in the relationship of relative intellectual efficiency and of relative proficiency in I.Q., mental age, and in visual memory span, a sixth group was selected from the cases making up group I. Group VI is composed of 72 fifth grade children having reverse spans of 5 or 6. Group VI, at the third grade level, consists of 171 cases having a reverse span of 4 or 5. Both Starr [11] and McCaulley [12] have stressed the diagnostic value of the reverse memory span and this claim was influential in the decision to make high reverse memory span a criterion for the selection of this sub-group. Our presupposition was that this would prove to be a superior group. The tables show that such is the case. However, as the age range for this group is from nine years and one month to thirteen years and eleven months, and as a reverse span of 5 is not nearly so good in the case of a child nearly fourteen years old as it is for a ten-year-old child, differences in whatever abilities the reverse span measures will be included within this group.

The average I.Q. is nearly three points higher than that of the "young" group, which is the next highest group with respect to I.Q. The median I.Q. of group VI is nearly five points higher than that of the "young" group. In passing it may be mentioned that the average I.Q. of 143 cases within group I having a reverse span of 2 or 3 was 90.6. Since the I.Q.'s of group VI are not influenced to as great an extent by lowness of chronological age as are those of the "young" group, the superiority of group VI in respect to I.Q. may be especially significant. This group is by far the best of the groups with respect to visual memory span. As compared with the whole group the index of significance is 7.09. The average visual memory span is 7.8 and alone of the groups the median is 8. This group is also relatively superior to the other groups in audito-vocal forward span. The average is about one digit higher than that of the other groups. The median mental age of this group is fourteen months higher than that of the total group and the difference is significant.

The criterion for the selection of a corresponding group at the

[11] Starr, A. S., The Diagnostic Value of the Audito-Vocal Digit Memory Span. *Psychological Clinic*, 1923, 15, Nos. 3–4.

[12] McCaulley, Selinda, A Study of the Relative Values of the Audito-Vocal Forward Memory Span and the Reverse Span as Diagnostic Tests. *Psychological Clinic*, 1928, 16, 277–291.

third grade level seemed to be a reverse span of 4 or 5. At this level also group VI is significantly superior to the whole group in I.Q., mental age, and in visual memory span.

Group VI may be said to resemble the "young" group in respect to the factors making for success in the tests now under consideration. Both sub-groups are relatively superior in these respects but the superiority of group VI appears to be more pronounced. Inspection of both the charts and of the tables for the third and fifth grade levels will make this clear. Thus it would appear that a high reverse memory span is a better criterion of intellectual superiority than is acceleration for grade. The high diagnostic value of the reverse span is confirmed. In spite of the fact that the median chronological age of group VI is six months higher than that of group V, which would have an influence upon the I.Q., the median I.Q. of group VI is five points higher than that of the "young" group. Should it be objected that the very fact of a high reverse span would tend to raise the I.Q. of group VI, we have still the higher visual span to consider.

To the positive relationship obtained between relative proficiency or deficiency in school progress (which we are calling "relative intellectual efficiency") and relative proficiency or deficiency in I.Q., visual memory span, and perhaps mental age, we now may add a positive relationship between these and the reverse memory span. To serve as a check upon this conclusion intercorrelations were made between I.Q., visual memory span and reverse memory span, at the fifth grade level. The "Product-Moment" method devised by Pearson was employed. The following *r's* were obtained: reverse memory span with I.Q., .436 $\pm$ .025; reverse memory span with visual memory span, .442 $\pm$ .023; I.Q. with visual memory span, .40 $\pm$ .025.

Since an "*r*" of + .40 may be regarded as indicative of a degree of correspondence analogous to that found to exist between siblings, these correlations although not high may be regarded as fitting in with the interrelationships otherwise obtained. The *r's* are approximately sixteen times their probable errors and the number of cases (500) is large. Therefore the conclusion may be drawn that a relationship exists between visual and reverse memory span, I.Q., perhaps mental age, and the factors making for success at school.

Part III

A Study of Groups IV, V, and VI with Regard to Relative Proficiency at the Non-verbal Performance Tests

If general competency may be defined as the ability "to succeed in the competitive events of a lifetime" or as the ability to make successful adaptations, we must think of it as an entity not entirely measurable but as involving an estimate based in part upon demonstrated proficiencies and upon other considerations not subject to measurement. The proficiencies which we have been considering, and between which we have found a relationship, are only some of the different proficiencies which can be demonstrated. It happens that they have a relationship to relative intellectual proficiency as we have defined it. Other proficiencies are required for success in the competitive events of a lifetime and it is with this in mind that observations and measurements are made of a number of test performances in the Psychological Clinic of the University of Pennsylvania. The three non-verbal performance tests most frequently employed are the Witmer Formboard, the Witmer Cylinders, and the Dearborn Formboard No. 1C. Reference is here made to the various "abilities" or competencies exhibited in the way the child manipulates concrete objects, comprehends the problem and carries it through to completion. Since it is of value in making an analytical diagnosis and an estimate of competency to discern as fully as possible the factors involved at different levels in the successful completion of a test, it seemed worth while to compare again groups IV, V, and VI, this time with reference to relative proficiency at these three performance tests. Since these groups vary in relative intellectual efficiency, a corresponding relative proficiency or deficiency in scores for any test would seem to imply that the problems presented by the test were intellectual in character. The absence of variation between groups would seem to indicate that quite other factors are dominant in successful performance or else that the test is too easy at that particular level. In this case it becomes an efficiency test at the given level. The assumption is made that relative proficiency in time scores corresponds to a greater development, refinement, or use of whatever abilities are involved in the performance of the test. Easby-Grave's study of first grade children would seem to negative this assumption at that level.

The Witmer Formboard

Considering first the statistical results obtained from treatment of test scores at the fifth grade level, we find that as between group and sub-group the differences are so slight as to be negligible. In no one of the groups does either the mean or median score vary as much as one second from that of the whole group. The sigmas and coefficients of variation are very similar and the obtained differences can in no instance be regarded as indicative of a true difference greater than zero between group and sub-group. At the third grade level the differences are slightly greater. The "old" group is possibly, not certainly, better and the "young" group is possibly poorer than the whole group. The "z's" are respectively 1.8 and 2.37. From this it appears that, except in cases of extreme deficiency, to give the Witmer Formboard as a test at the fifth grade level is superfluous. For the normal child within the fifth grade, this is merely a test of efficiency, as no real problem exists. Murphy, in the discussion of his results obtained at the fifth grade level, points out that the solution of the Witmer Formboard at this level is a display of efficiency rather than of intelligence. The present study further shows that it makes no distinction between the accelerated and the retarded children at this level. It may be slightly selective at the third grade level. The "young" and the "old" groups tend to rate respectively a little poorer and a little better quantitatively in its solution.

The Witmer Cylinder Test

This test is described by Paschal.[13] Inspection of results shows that the differences between the whole group and the sub-groups in average and median scores are not significant. In no case does the average score of any sub-group vary from the average of the whole group by as much as six seconds. This is true both when the failures are omitted and when they are included. In part I of this study it was indicated that groups II and III appear to be slightly better than the whole group in average score but that the differences are not statistically significant. When we examine the average and median scores of the accelerated and of the retarded groups, the latter appears to be slightly superior and the former slightly inferior in this test. Statistical treatment of these results indicates that there are 84 chances in 100 ("z" equals 1.02) that

[13] Paschal, F. C., The Witmer Cylinders. Hershey Press, Hershey, Pa.

there is a true difference greater than zero between the whole group and our "young" group. It is then possible, although not certain, that the young accelerated children within the fifth grade are relatively inferior in the performance of this test. At the third grade level inferiority on the part of the young accelerated children at the Witmer Formboard was found. Our "old" group IV, at the fifth grade level, shows seven failures at the Cylinder test as against five failures for the "young" group, but the decile ratings are poorer for the "young" group. Greater differences between the whole group and the sub-groups appear at the third grade level. The mean and median scores, both omitting and including failures, are better for the "old" group than for the whole group. The median is 30 seconds better in the case of the "old" group when we include failures. The mean score of the "young" group is about 20 seconds poorer than that of the whole group. The inclusion of failures accentuates the differences. While 16 out of 138 cases fail this test at the first trial, 39 out of 147 within the "young" group fail. The "*z*'s" (table IV) show that the "old" group is significantly better and the "young" group significantly poorer than the whole group at the third grade level. The real differences found at this level may be expressed in another form. Murphy states that at the fifth grade level 70.6 per cent accomplish the test in less than two minutes. If we apply the two-minute time limit to the "old" and "young" groups at this level it is found that 78 per cent of the former group succeed in performing the test within two minutes and that 76 per cent of the latter group succeed within that time limit; a difference of no significance. At the third grade level the following results were obtained: 72 per cent of "old" group succeed within *three* minutes; 54 per cent of "young" group succeed within *three* minutes. More than four minutes would be required to obtain 70 per cent of successes for the "young" group.

So we seem to find an inverse relationship between intellectual efficiency as we have defined it—together with the related proficiencies in I.Q., mental age, and the memory spans—and relative proficiency at the Witmer Cylinder test. The same thing may be true of the Witmer Formboard at the third grade level. Age, rather than relative intellectual efficiency, seems to make for success at the Cylinder test. Group VI, which pretty generally ranks highest in I.Q., mental age, and visual memory span, is not significantly different from the whole group in average score at the Cylinder test. Group VI at the third grade level shows 14 per

cent of failures at this test, while the "old" retarded group shows less than 12 per cent of failures. This is in accord with Paschal,[14] who standardized the Witmer Cylinder test. He calls attention to a continuous decrease in time of the means, quintiles, and medians with increasing age and finds a decreasing range of distribution also with increasing age. He regards the cylinders as a satisfactory test for adults as well as for young children. The findings of this present study reveal that while the test is selective of abilities of some sort at the third grade level, it is much less so at the level represented by the fifth grade. If results at this level have any significance, the older subjects seem to be superior.

All of this seems to indicate that proficiency ratings at the Witmer Cylinder test are not very significant at the fifth grade level. Like the Witmer Formboard it has, although to a less degree, become an efficiency test. This does not mean that the qualitative aspects of the performance of children at this level are not important. At the third grade level, the test is indicative of individual differences of some kind. The measures noted in the preceding paragraph and the more than double number of failures for the "young" as compared with the "old" group suggest that the differences brought out by this test are dependent upon other factors as well as upon those of efficiency. Probably the test is of value at this level, quantitatively as well as qualitatively. Upon whatever abilities success at this test depends, evidently they are other than those which characterize relative intellectual efficiency.

The Dearborn Formboard

Leaming states that the Dearborn Formboard[15] seems to provide a real intelligence test for the fifteen-year-old level. More recent investigations have disclosed that, reducing the time limit to five minutes, approximately 30 per cent of fifth grade children and about 70 per cent of third grade children fail. Clearly the test is too hard to be of much value at the third grade level, but it is surely of value at the fifth and probably at the fourth grade level. Leaming and others have indicated the great importance of this test. Because of its complexity "it gives the ex-

[14] Paschal, F. C., A Report on the Standardization of the Witmer Cylinder Test. *Psychological Clinic,* 1918, 12, 54–59.

[15] W. F. Dearborn, J. E. Anderson, A. Christiansen, Formboard and Construction Tests of Mental Ability. *Journal of Educational Psychology,* 1916, 7, 448.

aminer an insight into the way the child sets about solving new problems.'' Not only must the child employ the usual abilities displayed in the successful completion of a performance test, but the forms must be reconstructed in such a way as to fill up the empty spaces. Judgment is involved and displayed in the way that the subject goes about the solution of the problem.

Inspection of table 6 shows the remarkable similarity between the different results of the whole group and of the two sub-groups discussed in the first part of this study. When we turn our attention to groups IV and V we find that the ''old'' group (group IV) appears to be a little poorer than the whole group although statistically the difference is not significant. The ''*z*'' is 1.33. The apparent superiority of the ''young'' group to the whole group is about as great as the apparent inferiority of the ''old'' group. The differences are more pronounced when we include failures. With the ten minute time limit for successful performance of the test, 11.5 per cent of the ''old'' group and 5 per cent of the ''young'' group are unsuccessful. When we reduce the time limit to five minutes, less than 22 per cent of the ''young'' group fail while 34 per cent of the ''old'' group fail to complete the test. Statistically the superiority of the ''young'' group is not quite established. There are 99 chances in 100 (''*z*'' equals 2.3) of a true difference greater than zero between the whole group and this sub-group.

If we now look to the relative proficiency at the Dearborn Formboard of group VI, the group with high reverse memory span, we find very little difference between the means and medians of the whole group and sub-group when failures are omitted in the statistical treatment of results. The measures are shown in the tables. However, when we include failures, treating them as already indicated, the difference is emphasized. The mean of group VI is 29 seconds lower (better) than that of the whole group. The medians also of the sub-group are better. Making due allowance for the difference in size of the group and sub-group, failures occur with three times the frequency within the whole group. When we reduce the time limit to five minutes, over 27 per cent of the cases within group VI fail to accomplish this test. Thus while fewer failures, with the ten minute time limit, are found for this group with the high reverse span, with the shorter time limit the ''young'' group shows the lowest per cent of failures. Perhaps in this young accelerated group we meet with a speed factor which takes the

form in this test of a quicker perception of form relations, analysis of the problem, and quickness of problem solving ability. Statistically, there are 97 chances in 100 ("z" equals 1.9) that there is a true difference greater than zero between sub-group VI and the whole group.

The test scores of the groups which we are now studying at the third grade level were treated differently. Owing to the large number of failures which occurred the results are not tabulated. The per cent of failures for the whole group and for groups II and III are remarkably close, being 68, 70, and 68 respectively. 60.8 per cent of the "old" group fail and 73.4 per cent of the "young" group. This is the reverse of the findings at the fifth grade level. When we recall that the age range of the children composing the "young" group is from seven years and two months to eight years and five months, whereas the range for the "old" group is from nine years and five months to fourteen years and eight months, we are not surprised that the results are not comparable with those of similar groups of fifth grade children. Group VI, with the high reverse span, gives us the lowest per cent of failures among the third grade children; 58.4 per cent of this group are not successful at the Dearborn Formboard. However the age range of this group is from seven years and two months to fourteen years and four months. In view of these findings it seems proper to leave these third grade results out of our consideration and to confine our attention to the fifth grade children.

Finally, group IV, the "old" group, was compared with the "young" group V and with group VI (high reverse span) to find the reliability of the difference between these groups in the time required for performance of the Dearborn Formboard. The formula for diverse groups was used:

$$\text{sigma differences} = \sqrt{\text{sigma}^2(\text{av. } 1) + \text{sigma}^2(\text{av. } 2)}$$

in which sigma squared(av. 1) refers to the standard error of the average or mean of one group and sigma squared(av. 2) refers to the standard error of the average of the group with which it is compared. When groups IV and V are compared, it is found that the chances are 98 in 100 ("z" equals 2.1) that the true difference is greater than zero. When group VI is compared with group IV, there are 98 chances in 100 ("z" equals 2.1). In each case it is the "old" group which seems to be inferior. Thus the groups superior in I.Q. and in visual memory span seem to be superior at

the Dearborn Formboard—although statistically there is not quite absolute certainty—to group IV, which is relatively inferior in I.Q. and in visual memory span. The reference is to children at the fifth grade level.

Summarizing the findings relative to the proficiencies of the whole fifth grade group and of the sub-groups, we find that the "young" group and the group characterized by high reverse span appear to be superior at this test, although we do not obtain statistical certainty. Leaving failures out of consideration, the "young" group may prove to be a little quicker in the performance of the test. With the short time limit, the per cent of failures is lowest for the "young" group; with the long time limit the per cent of failures is lowest for group VI. The "old" group is probably poorer at this test and gives relatively more failures. Relating these findings to those of part 2, we state that those groups which proved to be relatively more superior in I.Q., mental age, and visual memory span, also show relative superiority at the Dearborn Formboard. Group IV—the "old" group—is relatively deficient in these factors and at the Dearborn Formboard.

Scores at the three performance tests were then correlated with I.Q. and reverse memory span, using the "Product-Moment" method. The following "*r*'s" were obtained:

	With Dearborn Formboard	Witmer Cyl.	Witmer Formboard
Reverse Memory Span with	+ .137 ± .029	+ .026 ± .03	+ .042 ± .03
I.Q. with	+ .227 ± .029	+ .095 ± .049	

Ninety-eight cases within group III were treated as follows, employing the Otis correlation sheet, and yielded the following *r*'s: Dearborn Formboard with mental age .206; Witmer Cylinders with mental age .049.

All of these correlations are low. There is a slightly higher "*r*" for the Dearborn Formboard with I.Q. and reverse memory span than in the case of the other performance tests. Apart from the correlations, we seem to be justified in drawing the conclusion that the factors making for relative proficiency at the Dearborn Formboard are more intellectual in nature than in the case of the Witmer Formboard and Cylinders.

General Discussion

At the third grade level, the Cylinder test seems to be selective of relative superiority or inferiority in whatever abilities are involved in rapid performance of the test. Since the "old" group is significantly better and the "young" group significantly poorer than the whole group and since 91 failures occur within the whole group, the test does seem to present a problem at this level. Efficiency rather than intelligence on the part of fifth grade children appears to be involved in success at the Cylinder test. Only 17 failures occur within the whole group and the apparent differences between the sub-groups are much less pronounced. Proficiency ratings are of little significance except as efficiency indices. There appears to be no positive relationship between what we have called "relative intellectual efficiency" and relative proficiency at the Cylinders. Whatever relationship may exist, appears to be a negative one. Relative proficiency in terms of this test may exist at a low intellectual level. Whatever abilities are tested, in the case of third grade children, are probably more specific in nature, may have little relationship to each other and certainly are not related to the group of "intellectual" abilities.[16]

The complex of abilities involved in relative proficiency at the Dearborn Formboard includes those which are related to mental complexity of the kind probably tapped by the memory span tests. The fact that the "old" group is probably relatively inferior at the Dearborn test suggests that the relative deficiency of the "old" group in the factors making for progress at school more than outweighs the contribution of more specific abilities also involved in successful completion of the test.

Conclusions

1. For practical purposes in securing norms for fifth grade children, essentially the same results would be secured if the children composing the middle 40 per cent in chronological age range were tested as were secured by testing 500 children. Nearly the same results would be secured by testing the middle 20 per cent in age range. This is not true of I.Q.

2. A close relationship exists between the abilities represented in visual and reverse memory span, I.Q., and the factors making for proficiency in progress through the grades.

[16] Freeman, F. N., Mental Tests. New York: Houghton and Mifflin. 1926.

3. Proficiency ratings at the Witmer Formboard and the Witmer Cylinders are not significant at the fifth grade level except as efficiency indices.

4. The findings of this study indicate that the visual memory span is as indicative of intellectual competency as is the reverse span.

5. The factors making for relative proficiency at the Dearborn Formboard appear to be of a more "intellectual" nature than those making for success at the Witmer Formboard or Cylinders.

BIBLIOGRAPHY

Brotemarkle, R. A. Some Memory Span Problems—An Analytical Study at the College Adult Level. *Psychological Clinic,* 1924, 15, 229–258.

Dearborn, W. F., Anderson, J. E., Christiansen, A. O. Formboard and Construction Tests of Mental Ability. *Journal of Educational Psychology,* 1916, 7, 445–458.

Easby-Grave, Charlotte. Tests and Norms at the Six Year Old Performance Level. *Psychological Clinic,* 1924, 15, 261–300.

Fernberger, S. W. Statistical and Non-Statistical Interpretation of Test Results. *Psychological Clinic,* 1922, 14, 68–72.

Freeman, F. N. Mental Tests. Houghton Mifflin Co. 1926.

Garrett, Henry E. Statistics in Psychology and Education. Longmans, Green and Co. 1926.

Jones, Alice M. An Analytical Study of One Hundred Twenty Superior Children. *Psychological Clinic,* 1925, 16, 19–76.

Leaming, R. E. Tests and Norms for Vocational Guidance at the Fifteen Year Old Performance Level. *Psychological Clinic,* 1922, 14, 193–220.

McCaulley, Selinda. A Study of the Relative Values of the Audito-Vocal Forward Memory Span and the Reverse Span as Diagnostic Tests. *Psychological Clinic,* 1928, 16, 277–291.

Murphy, Miles. The Ten Year Level of Competency. *Psychological Clinic,* 1928, 17, 33–60.

Paschal, F. C. The Witmer Cylinders. Hershey Press, Hershey, Pa.

——. A Report on the Standardization of the Witmer Cylinder Test. *Psychological Clinic,* 1918, 12, 54–59.

Starr, A. S. The Diagnostic Value of the Audito-Vocal Digit Memory Span. *Psychological Clinic,* 1923, 15, Nos. 3–4.

Witmer, Lightner. Intelligence—A Definition. *Psychological Clinic,* 1922, 14, 65–67.

——. Psychological Diagnosis and the Psychonomic Orientation in Analytical Science. *Psychological Clinic,* 1925, 16, 1–18.

STATISTICAL TABLES *

Fifth Grade Level

Table I
Intelligence Quotient

Group	Cases	Mean	Sigma	Sk.	V.	P.E. Mean	Sigma diff.	"z"
I	500	98.9	16.8	−.07	16.9	.50		
II	215	101.3	12.8	.23	12.7	.58	.813	2.9
III	98	103.1	11.5	.44	11.1	.78	1.17	3.5
IV	148	83.3	12.4	.06	15.0	.68	.88	17.6
V	137	111.9	12.8	.61	11.4	.73	.94	13.8
VI	72	114.6	16.6	.06	14.5	1.3	1.79	8.7

Table II
Mental Age

Group	Cases	Mean	Sigma	Sk.	V.	P.E. Mean	Sigma diff.	"z"
I	500	130.3	14.9	.36	11.4	.44		
II	215	131.6	15.3	.51	11.6	.69	.77	1.7
III	98	133.4	14.3	.34	10.8	.97	1.3	2.38
IV	148	126.3	14.0	.12	11.1	.77	.98	4.06
V	137	132.6	14.4	.29	10.8	.83	1.10	2.1
VI	72	144.5	16.1	.54	11.1	1.26	1.71	8.3

Table III
Visual Memory Span

Group	Cases	Mean	Sigma	P.E. Mean	Sigma diff.	"z"
I	500	6.89	1.04	.03		
II	215	6.91	.97	.05	.05	.38
III	98	6.87	.96	.06	.09	.29
IV	148	6.59	1.05	.06	.08	3.9
V	137	7.22	.98	.06	.07	4.4
VI	72	7.8	1.06	.08	.11	7.09

Table IV
Witmer Formboard (First Trial)

Group	Cases	Mean	Sigma	Sk.	V.	P.E. Mean	Sigma diff.	"z"
I	500	26.3	6.3	.52	23.9	.19		
II	215	26.9	6.3	.52	23.2	.28	.32	2.1
III	98	26.9	6.8	.59	25.3	.46	.605	.99
IV	148	26.0	6.69	.69	25.7	.37	.45	.7
V	137	25.7	5.78	.31	22.5	.33	.42	1.4
VI	72	25.8	5.93	.46	22.9	.46	.65	.77

* Notes on the Tables.

The following tables do not include the results for the visual memory span and the Dearborn Formboard at the third grade level. The decile tables for group VI are likewise omitted in both grades. Mental age is shown in months; time for the performance tests is given in seconds. Unless otherwise indicated the skewness is positive. In only two cases was it negative; the plus signs were omitted where the skewness was positive. The numbers in parentheses after "F" indicate number of failures.

TABLE V

WITMER CYLINDERS (FIRST TRIAL)

Group	Cases	Mean	Sigma	Sk.	V.	P.E. Mean	Sigma diff.	"z"
I	500	99.7	61.2	1.0	61.0	1.82		
		98.4	*48.0*	*.92*	*51.8*			
II	215	96.9	53.4	.88	55.1	2.43	3.04	.92
		91.8	*42.9*	*.82*	*46.7*			
III	98	93.5	53.8	.97	57.6	3.64	5.04	1.23
		86.7	*38.7*	*.93*	*44.6*			
IV	148	99.1	66.4	1.23	67.0	3.64	4.42	.13
		88.7	*48.6*	*1.13*	*54.8*			
V	137	104.5	66.1	1.01	63.0	3.78	4.67	1.02
		96.8	*53.7*	*.88*	*59.0*			
VI	72	97.0	56.1	.96	57.8	4.42	10.29	.26
		91.0	*44.1*	*.88*	*48.4*			

TABLE VI

DEARBORN FORMBOARD (FIRST TRIAL)

Group	Cases	Mean	Sigma	Sk.	V.	P.E. Mean	Sigma diff.	"z"
I	500	259.8	162.2	.95	62.4	4.87		
		223.8	*122.1*	*.78*	*54.5*			
II	215	265.2	168.6	.88	63.0	7.68	8.43	.64
		226.7	*127.2*	*.79*	*56.0*			
III	98	257.1	160.9	.94	62.2	10.89	14.6	.18
		225.3	*125.7*	*.81*	*55.8*			
IV	148	275.5	168.6	.89	61.0	9.27	11.79	1.33
		231.4	*123.7*	*.83*	*54.0*			
V	137	234.6	140.5	.87	59.0	8.04	10.83	2.3
		214.2	*112.1*	*.73*	*52.3*			
VI	72	230.8	135.1	.90	58.5	10.65	15.25	1.9
		220.0	*120.3*	*.86*	*54.7*			

THIRD GRADE LEVEL

TABLE I

INTELLIGENCE QUOTIENT

Group	Cases	Mean	Sigma	Sk.	V.	P.E. Mean	Sigma diff.	"z"
I	496	99.9	14.4	.03	14.3	.43		
II	211	100.9	11.5	.24	11.4	.53	.88	1.19
III	115	101.2	12.5	.53	12.3	.78	1.06	1.27
IV	138	88.1	13.5	.15	15.0	.76	.94	12.5
V	147	109.5	11.1	.24	10.2	.61	.82	11.7
VI	171	106.1	14.9	−.01	14.0	.76	.88	7.0

TABLE II

MENTAL AGE

Group	Cases	Mean	Sigma	Sk.	V.	P.E. Mean	Sigma diff.	"z"
I	496	108.5	11.4	.13	10.5	.34		
II	211	108.6	11.3	.18	10.4	.52		
III	115	108.6	12.5	.43	11.5	.78		
IV	138	109.3	12.7	.07	11.6	.72	.88	.90
V	147	107.7	10.1	.15	9.3	.56	.74	1.1
VI	171	114.1	11.4	.34	9.9	.58	.68	8.1

TABLE III
WITMER FORMBOARD (FIRST TRIAL)

Group	Cases	Mean	Sigma	Sk.	V.	P.E. Mean	Sigma diff.	"z"
I	496	34.8	9.7	.64	28.0	.29		
II	211	34.5	9.0	.24	26.0	.41	.498	.52
III	115	33.5	7.9	.16	23.5	.49	.693	1.8
IV	138	33.4	10.8	.54	32.0	.61	.75	1.8
V	147	36.3	8.9	.62	24.0	.49	.64	2.37
VI	171	35.2	10.2	.90	29.0	.52	.51	.77

TABLE IV
WITMER CYLINDERS (FIRST TRIAL)

Group	Cases	Mean	Sigma	Sk.	V.	P.E. Mean	Sigma diff.	"z"
I	496	168.1	87.1	.67	51.8	2.62		
		136.5	*62.2*	*.53*	*45.0*	*2.07*		
II	211	171.1	83.9	.79	49.0	3.88	4.53	.66
		142.9	*61.8*	*.47*	*43.0*	*3.14*		
III	115	162.3	84.7	.76	52.0	5.48	6.97	.83
		138.6	*65.7*	*.74*	*47.0*	*4.4*		
IV	138	141.8	81.7	.87	57.0	4.66	6.02	4.3
		119.9	*62.4*	*.94*	*52.0*	*3.8*		
V	147	188.2	87.7	.55	46.0	4.85	6.02	3.3
		144.8	*59.5*	*.63*	*41.0*	*3.77*		
VI	171	159.4	84.9	.69	53.0	4.35	5.4	1.6
		133.9	*60.6*	*.41*	*45.0*	*3.36*		

DECILE TABLES

FIFTH GRADE LEVEL

GROUP I

C.A.	M.A.	%	I.Q.	M.S. Aud.	M.S. Vis.	M.S. Rev.	Wtmr. Fb. I	Wtmr. Fb. II	Cyl. I	Cyl. II	Dbn. Fb. I	Dbn. Fb. II	Arith.
17–3	16–0	100	156.1	9	10	6	12	12	32	24	41	35	100
15–2	14–5	99	137.7	8	9	6	16	13	39	30	55	38	100
12–11	12–6	90	119.9	7	8	5	19	16	49	40	96	57	95
12–1	11–9	80	112.6	6	8	4	21	18	57	45	125	70	90
11–6	11–4	70	107.1	6	7	4	22	19	64	50	145	83	85
11–1	10–11	60	103	6	7	4	23	20	69	53	174	95	80
10–10	10–8	50	99.3	6	7	4	25	21	77	57	209	106	70
10–7	10–5	40	94.9	5	7	4	26	22	87	60	253	126	65
10–4	10–2	30	89.6	5	6	4	28	23	98	65	304	153	60
10–1	9–10	20	84.6	5	6	3	30	25	126	71	378	194	50
9–10	9–6	10	77.2	5	6	3	35	28	183	83	580	264	40
9–2	8–3	1	61.2	4	5	2	46	57	F	146	F	F	10
8–11	7–3	0	54	3	5	2	51	93	F(17)	F(1)	F(46)	F(14)	0

GROUP II

C.A.	M.A.	%	I.Q.	M.S. Aud.	M.S. Vis.	M.S. Rev.	Wtmr. Fb. I	Wtmr. Fb. II	Cyl. I	Cyl. II	Dbn. Fb. I	Dbn. Fb. II	Arith.
11–6	15–6	100	146.4	9	10	6	15	13	32	29	41	37	100
11–6	14–1	99	133.6	8	9	6	16	13	42	31	52	37	100
11–4	12–9	90	117.8	7	8	5	20	17	52	42	87	56	95
11–2	11–10	80	111.1	6	8	4	21	18	60	46	125	70	90
11–0	11–4	70	105.5	6	7	4	23	19	65	50	149	82	85
10–11	11–0	60	102.4	6	7	4	24	20	71	53	177	94	75
10–9	10–8	50	100	6	7	4	25	21	78	56	217	105	70
10–8	10–5	40	96.8	5	7	4	27	23	90	60	263	130	65
10–7	10–2	30	94.5	5	6	4	29	24	98	63	327	156	60
10–6	9–11	20	89.8	5	6	3	31	25	120	69	396	206	50
10–5	9–6	10	85.8	5	6	3	35	29	158	75	F	301	40
10–4	8–6	1	77.2	4	5	2	45	37	F	156	F	F	10
10–4	8–3	0	71.4	3	5	2	49	49	F(5)	F(1)	F(22)	F(7)	0

GROUP III

C.A.	M.A.	%	I.Q.	M.S. Aud.	M.S. Vis.	M.S. Rev.	Wtmr. Fb. I	Wtmr. Fb. II	Cyl. I	Cyl. II	Dbn. Fb. I	Dbn. Fb. II	Arith.
11	15–6	100	146.4	8	9	6	15	13	32	34	46	37	100
11	12–8	90	117.1	7	8	5	20	17	54	43	89	56	95
10–11	11–10	80	109.9	6	8	4	21	18	58	47	127	72	90
10–11	11–4	70	106.2	6	7	4	23	19	64	50	149	85	80
10–10	11–1	60	103.1	6	7	4	25	20	70	53	174	90	75
10–9	10–10	50	100.7	6	7	4	26	21	75	57	209	102	70
10–8	10–8	40	98.4	6	7	4	26	22	87	61	261	128	65
10–8	10–5	30	96.9	5	6	4	28	23	97	65	329	149	60
10–7	10–2	20	95.2	5	6	3	30	25	113	69	372	180	50
10–7	9–10	10	89.8	5	6	3	37	29	155	75	586	303	35
10–7	8–9	0	80.1	3	5	2	49	34	F(3)	156	F(8)	F(3)	0

GROUP IV

C.A.	M.A.	%	I.Q.	M.S. Aud.	M.S. Vis.	M.S. Rev.	Wtmr. Fb. I	Wtmr. Fb. II	Cyl. I	Cyl. II	Dbn. Fb. I	Dbn. Fb. II	Arith.
17–3	14–5	100	117.9	8	10	6	12	12	35	24	41	36	100
16–11	13–8	99	116.1	8	10	5	15	13	36	29	66	38	100
14–1	11–11	90	98.9	6	8	4	19	17	48	37	110	61	95
13–5	11–4	80	92.8	6	7	4	20	18	54	41	132	71	90
13–1	10–11	70	87.7	6	7	4	21	19	60	44	150	85	85
12–9	10–8	60	85.9	6	7	4	22	20	65	49	184	94	80
12–6	10–6	50	83.1	5	7	4	24	20	68	52	234	105	70
12–3	10–2	40	80.6	5	6	4	25	21	81	60	273	123	65
12–0	9–10	30	76.6	5	6	3	27	22	97	62	343	150	60
11–10	9–7	20	72.7	5	6	3	30	25	127	68	415	180	50
11–8	9–0	10	67.1	5	5	3	35	27	190	81	F	287	35
11–7	7–3	1	54	4	5	2	51	93	F	282	F	F	10
11–7	7–3	0	54	4	5	2	51	93	F(7)	282	F(17)	F(6)	10

GROUP V

C.A.	M.A.	%	I.Q.	M.S. Aud.	M.S. Vis.	M.S. Rev.	Wtmr. Fb. I	Wtmr. Fb. II	Cyl. I	Cyl. II	Dbn. Fb. I	Dbn. Fb. II	Arith.
10–3	16–0	100	156.1	9	10	6	15	12	36	30	55	35	100
10–3	14–4	99	151.3	8	10	6	16	14	42	31	59	38	100
10–3	12–6	90	128.7	7	8	5	19	16	52	44	102	55	100
10–2	11–11	80	121.1	7	8	4	20	17	60	50	125	68	90
10–1	11–6	70	117.2	6	8	4	22	18	66	53	135	82	85
10–0	11–2	60	112.5	6	7	4	23	20	75	56	162	100	80
9–11	10–10	50	109	6	7	4	25	20	80	60	190	111	75
9–10	10–8	40	107.3	6	7	4	25	21	88	65	231	125	70
9–8	10–4	30	105.7	5	7	4	28	22	101	71	275	146	60
9–7	10–0	20	101.6	5	6	3	29	24	132	78	330	189	50
9–5	9–7	10	97.5	5	6	3	33	27	205	96	427	223	40
8–11	7–3	1	71.3	4	5	3	46	72	F	134	F	F	25
8–11	7–3	0	71.3	4	5	3	46	72	F(5)	134	F(7)	F(1)	25

Third Grade Level

Group I *

C.A.	M.A.	%	I.Q.	M.S. Aud.	M.S. Vis.	M.S. Rev.	W.F.B. I	W.F.B. II	Cyl. I	Cyl. II	D.F.B. I	D.F.B. II
14–4	13–9	100	143.7	9	10	5	14	12	39	32	35	37
12–10	11–10	99	137.5	8	9	5	17	16	45	38	82	46
10–2	10–3	90	119.2	7	8	4	24	20	70	54	158	84
9–8	9–8	80	112.2	6	7	4	26	22	85	60	231	110
9–4	9–4	70	107.5	6	7	4	29	24	97	65	285	132
9–0	9–2	60	103.9	6	7	3	30	25	120	70	F	160
8–10	9–0	50	100.3	5	6	3	32	26	142	77	F	190
8–8	8–9	40	96.6	5	6	3	35	28	165	83	F	230
8–6	8–6	30	92.8	5	6	3	37	30	198	91	F	300
8–3	8–3	20	88.4	5	6	3	40	32	260	109	F	F
8–1	7–9	10	81.8	5	5	3	46	37	F	145	F	F
7–7	7–0	1	67.5	4	5	2	90	80	F	F	F	F
7–5	6–6	0	59.4	4	4	2	285	117	F	F	F	F

Group II

C.A.	M.A.	I.Q.	%	M.S. Aud.	M.S. Vis.	M.S. Rev.	W.F.B. I	W.F.B. II	Cyl. I	Cyl. II	D.F.B. I	D.F.B. II
9–4	12–5	143.7	100	9	10	5	17	15	50	32	75	37
9–4	11–5	132	99	8	8	5	20	16	60	40	85	54
9–3	10–3	116.3	90	7	8	4	25	21	75	54	158	91
9–2	9–7	109.5	80	6	7	4	27	23	90	60	256	116
9–	9–3	105.5	70	6	7	4	29	24	106	65	F	138
8–11	9–	102.9	60	6	6	3	30	25	131	72	F	168
8–10	8–10	100	50	5	6	3	31	26	148	78	F	197
8–9	8–9	97.2	40	5	6	3	35	28	181	85	F	242
8–8	8–4	94.2	30	5	6	3	37	30	205	95	F	F
8–7	8–3	91.1	20	5	6	3	41	34	273	114	F	F
8–6	7–9	87.7	10	5	5	3	46	40	F	175	F	F
8–6	7–	77.7	1	4	5	2	190	100	F	F	F	F
8–6	7–	75	0	4	5	2	285	117	F(36)	F(3)	F(148)	F(67)

Group III

C.A.	M.A.	I.Q.	%	M.S. Aud.	M.S. Vis.	M.S. Rev.	W.F.B. I	W.F.B. II	Cyl. I	Cyl. II	D.F.B. I	D.F.B. II
9	12–5	143.7	100	8	10	5	17	15	50	32	75	46
9	11–7	132.3	99	8	8	5	19	16	60	36	85	54
9	10–5	117.5	90	6	8	4	23	21	70	52	154	84
9–	9–10	111.3	80	6	7	4	27	22	82	58	255	111
8–11	9–6	106.7	70	6	7	4	29	24	97	63	291	138
8–11	9–	102.7	60	6	7	3	30	25	115	69	F	168
8–10	8–9	98.1	50	5	6	3	31	25	138	75	F	197
8–10	8–6	95.3	40	5	6	3	34	27	171	83	F	232
8–9	8–3	93.3	30	5	6	3	37	30	196	88	F	295
8–9	8–	90.5	20	5	6	3	40	32	260	111	F	F
8–8	7–9	87.7	10	5	5	3	44	37	F	173	F	F
8–8	7	77.7	1	4	4	2	90	117	F	F	F	F
8–8	7	77.7	0	4	4	2	90	117	F(16)	F(1)	F(79)	F(32)

* This table includes only the first 400 cases of the group to be examined.

GROUP IV

C.A.	M.A.	I.Q.	%	M.S. Aud.	M.S. Vis.	M.S. Rev.	W.F.B. I	W.F.B. II	Cyl. I	Cyl. II	D.F.B. I	D.F.B. II
14–8	13–9	143.7	100	8	9	5	14	12	39	33	35	39
14–4	13–6	140.9	99	7	9	5	16	14	40	37	62	44
11–6	10–3	101.5	90	6	7	4	22	20	56	48	141	77
10–11	9–6	96.5	80	6	7	4	25	21	67	57	207	92
10–5	9–3	93.2	70	6	7	4	26	23	81	62	237	113
10–2	9–	90.2	60	6	6	3	29	24	91	65	F	145
10–	9–	86.8	50	5	6	3	31	25	120	71	F	181
9–10	8–9	83.9	40	5	6	3	33	27	151	78	F	212
9–8	8–6	81.8	30	5	6	3	36	29	167	87	F	284
9–7	8–	78.2	20	5	6	3	40	30	215	102	F	F
9–6	7–9	71.9	10	5	5	2	46	34	F	131	F	F
9–5	6–6	54.5	1	4	5	2	110	75	F	F	F	F
9–5	6–6	54.5	0	4	5	2(17)	110	75	F(16)	F(1)	F(84)	F(34)

GROUP V

C.A.	M.A.	I.Q.	%	M.S. Aud.	M.S. Vis.	M.S. Rev.	W.F.B. I	W.F.B. II	Cyl. I	Cyl. II	D.F.B. I	D.F.B. II
8–5	11–4	142.8	100	8	9	5	21	17	67	47	88	69
8–5	10–10	139.3	99	8	9	5	21	17	71	47	95	76
8–5	10–1	122.9	90	6	8	4	25	21	84	60	222	110
8–4	9–8	119.1	80	6	7	4	29	23	100	66	274	129
8–3	9–3	114.8	70	6	7	4	31	25	114	75	F	152
8–3	9–	111.2	60	6	7	3	32	26	146	80	F	174
8–2	8–9	108.4	50	6	6	3	35	28	175	85	F	214
8–2	8–6	105.6	40	5	6	3	36	29	199	96	F	258
8–	8–6	103.9	30	5	6	3	40	31	259	106	F	F
7–11	8–3	101	20	5	6	3	43	35	F	122	F	F
7–9	7–9	96.9	10	5	5	3	50	39	F	164	F	F
7–2	6–9	81	1	4	5	2	105	80	F	F	F	F
7–2	6–9	81	0	4	5	2	105	80	F(39)	F(1)	F(108)	F(51)

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